

# **September 1996 Preliminary Data Summary**

by Field Research Facility

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# Preface

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This report provides a summary of basic oceanographic, meteorological and bottom profile data for the month. The data were obtained as part of the Measurements and Analysis work units at the U.S. Army Engineer Waterways Experiment Station, Coastal and Hydraulics Laboratory's Field Research Facility (FRF) in Duck, North Carolina. The FRF staff collected and analyzed these data. These summaries are intended to make the data readily available to all FRF users, and comments on their content and usefulness are invited.

***Data from these reports are now available via the World Wide Web at <http://www.frf.usace.army.mil>***

These web pages contain general information about the Field Research Facility and data from 1980 to the present.

Please note the new web address, <http://www.frf.usace.army.mil>

Your comments and criticisms are welcome.

# Introduction

## 1

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The U.S. Army Engineer Waterways Experiment Station, Coastal and Hydraulics Laboratory's (CHL) Field Research Facility (FRF) is located on the Outer Banks of North Carolina, near the village of Duck (Figure 1).

The FRF research program provides a means for obtaining high-quality field data, particularly during storms, in support of the U.S. Army Corps of Engineers' coastal engineering research missions. The research pier is a reinforced concrete structure supported on 0.9-m-diam steel piles spaced 12.2 m apart along the pier's length and 4.6 m apart across the width. The pier deck is 6.1 m wide and extends from behind the duneline to about the 6-m water depth contour at a height of 7.75 m above the National Geodetic Vertical Datum (NGVD) of the year 1929.

One of the responsibilities of the FRF research program is the collection, analysis and dissemination of data on local bathymetric, oceanographic, and meteorological conditions. This summary is intended to provide basic data as soon as possible after they are obtained. Questions and/or comments concerning the data may be directed to Mr. Clifford F. Baron at (919) 261-3511 (*c.baron@cerc.wes.army.mil*).

Chapter 2 presents the meteorological data; Chapters 3 through 6 present oceanographic data; Chapter 7 presents nearshore profiles and bathymetry; and Chapter 8, if included, documents special events that occurred at the FRF during the month.

Table 1 is a list of instruments used and their operational status during the month. Figure 2 shows weather and ocean conditions for the month. Table 2 and Figure 3 identifies the location of the instruments. The water depths at the wave gauges and current meters vary and may be determined from information contained in Figure 9. Other installation information is contained in Table 1.

Times given in the report are referenced to Eastern Standard Time (EST).

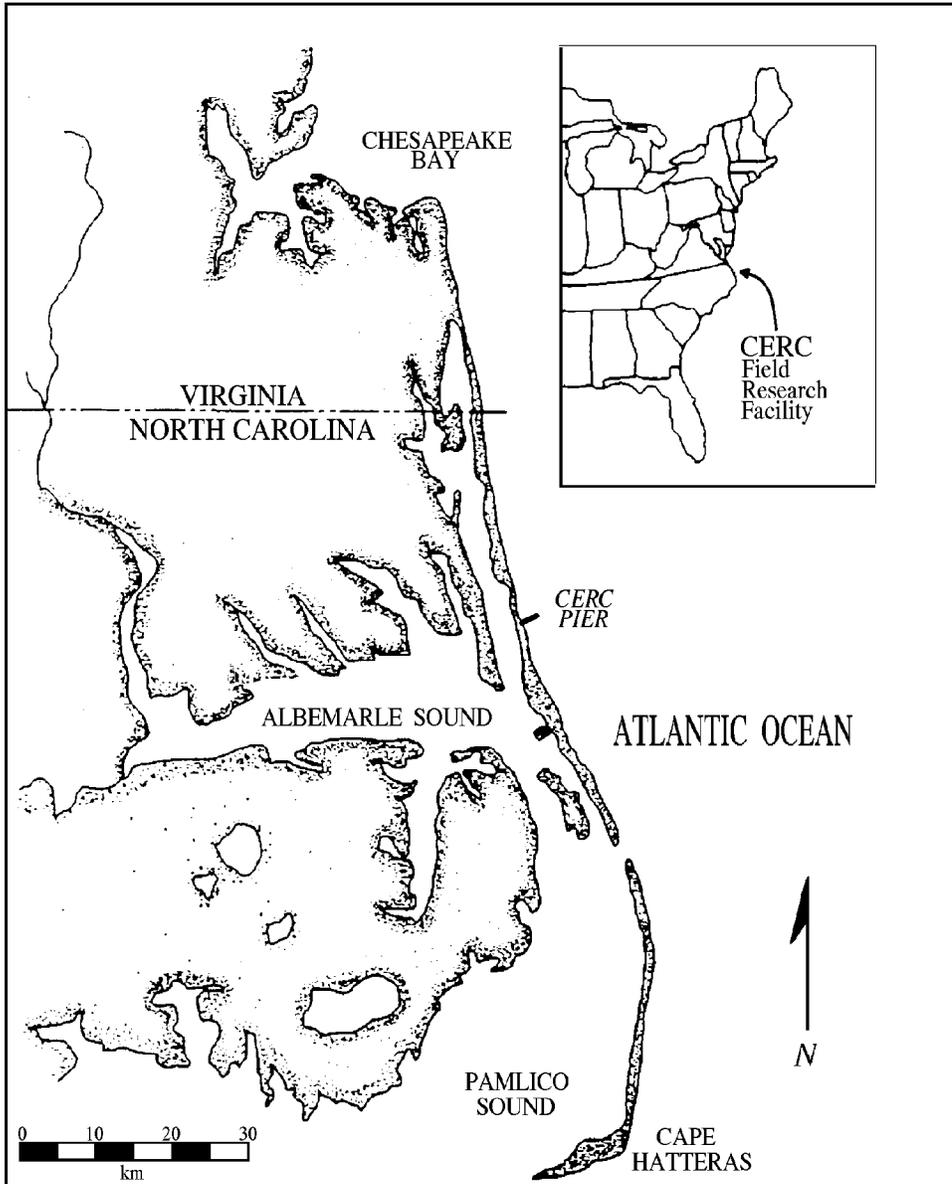


Figure 1. FRF Location Map

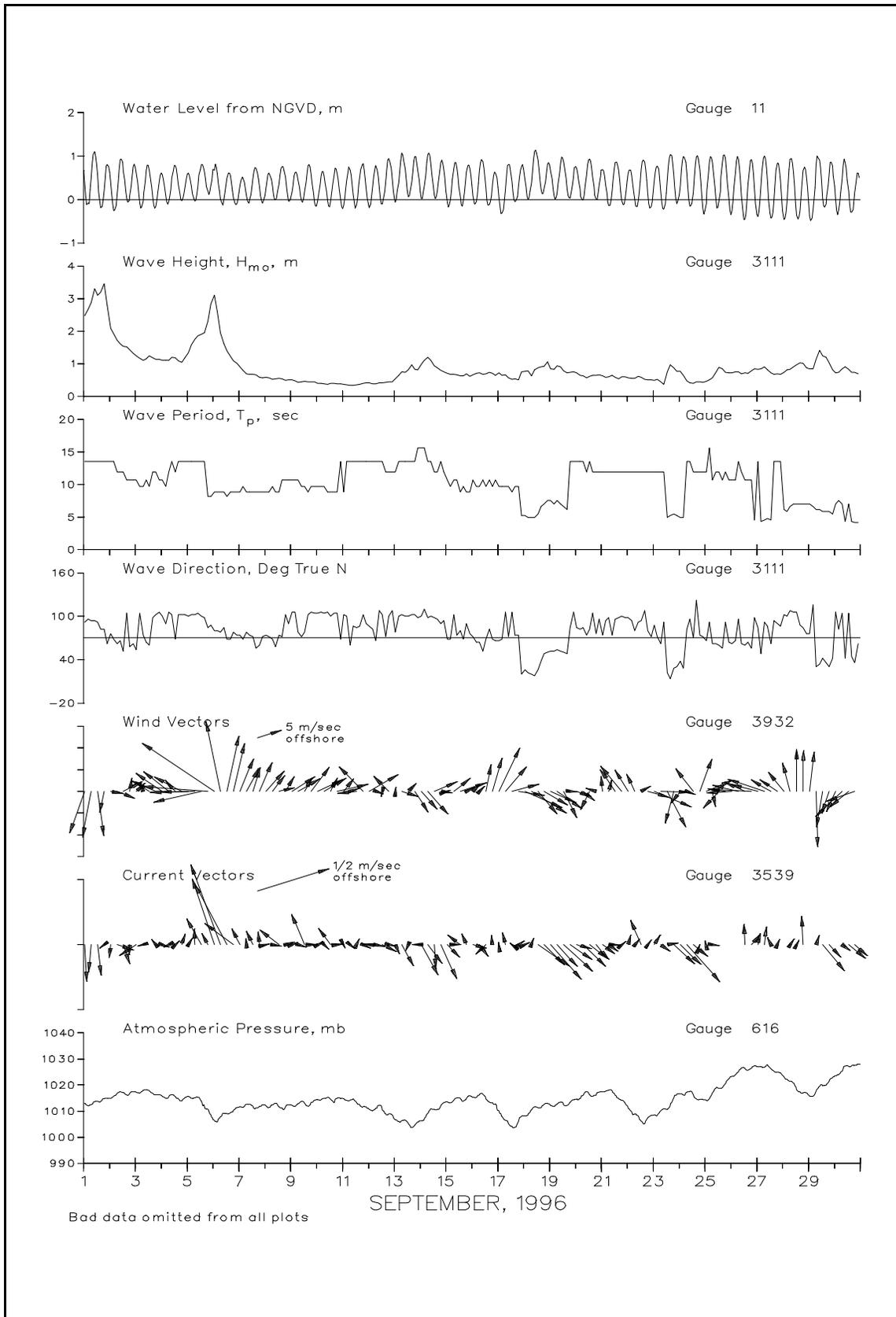


Figure 2. Month at a Glance

**Table 1  
Instrument Status/Data Availability**

			September 1996																														
			Day of the month																														
Gauge ID	Description/Remarks		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
616	Atmospheric Pressure	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
604	Precipitation	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
624	Air Temperature	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	/	-	/	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
3932	Anemometer	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
641	Pressure Gauge on FRF pier	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
625	Baylor staff on FRF pier	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
3111	8 Meter Array 309 m north of FRF	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
111	Pressure Gauge center of 8 Meter Array	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
630	Waverider buoy 4.0 km offshore	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
3539	Current meter 343 m north of FRF pier (1.6 km offshore)	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	/	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	/	/	/	/	/
11	NOAA tide gauge at end of pier	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
	Visual Observations (daily oceanographic and meteorological observations)	Daily observation	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Gauge Status			* = Operational / = Partial - = Non-Operational																														
Data Collected			* = All / = Partial - = None																														
Visual Observations			* = Complete / = Partial - = None																														

**Table 2  
Gauge Locations**

Gauge ID	Description	Latitude Degrees N	Longitude Degrees W	FRF Coordinates Crossshore T m	FRF Coordinates Longshore m	Gauge Depth NGVD, m	Water Depth NGVD, m
616	Atmospheric Pressure	36 10' 57.03"	75 45' 5.50"	11.60	569.00	-----	-----
3932	Anemometer	36 11' 1.23"	75 44' 43.07"	585.20	517.30	19.50	-----
641	Pressure Gauge	36 10' 57.71"	75 44' 56.23"	239.11	516.64	-1.64	-1.96
625	Baylor Staff	36 11' 1.04"	75 44' 43.72"	568.00	516.64	Surface	-8.36
3111	8 Meter Array North	36 11' 19.14"	75 44' 36.41"	915.23	990.16	-7.50	-7.90
	8 Meter Array South	36 11' 11.28"	75 44' 33.28"	914.20	735.37	-7.42	-7.90
	8 Meter Array East	36 11' 13.70"	75 44' 32.56"	954.51	800.58	-7.62	-8.13
	8 Meter Array West	36 11' 12.48"	75 44' 37.11"	834.66	800.37	-6.98	-7.44
111	Pressure Gauge in center of 8 M Array	36 11' 14.06"	75 44' 34.39"	914.43	825.52	-7.76	-8.08
630	Waverider Buoy	36 10' 5.10"	75 41' 59.30"	3934.96	-2400.81	Surface	-17.00
3539	Current Meter	36 11' 23.57"	75 44' 9.12"	1605.80	907.60	-11.60	-11.70
11	NOAA Tide Gauge	36 11' 1.25"	75 44' 42.60"	596.49	514.20	Surface	-7.62
R	R	R	R	R	R	R	R

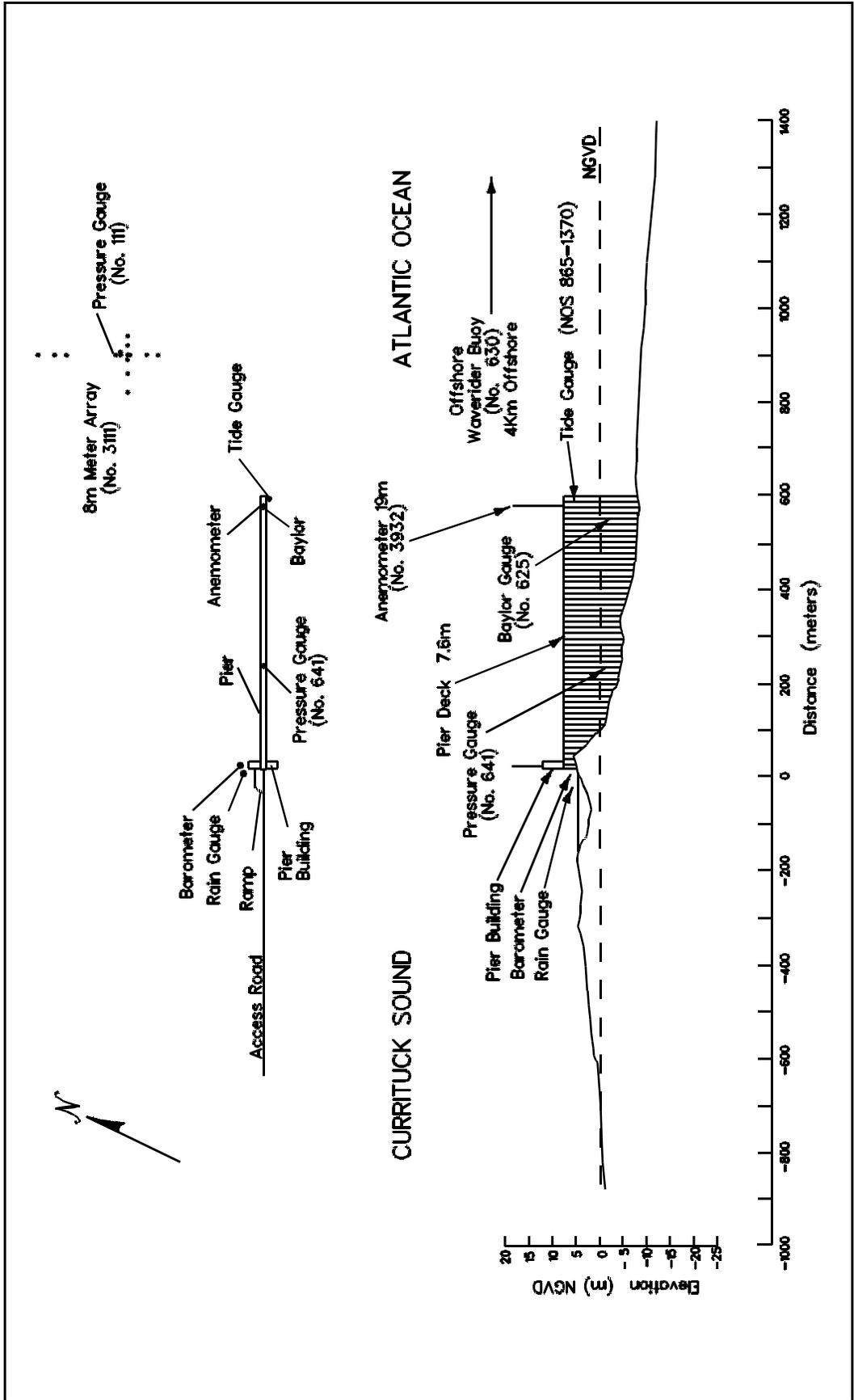


Figure 3. Instrument Locations, Elevations From NGVD

# Meteorological Data

## 2

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A variety of instruments have been installed at the FRF (Figure 3) to monitor the meteorological conditions. The data presented in Table 3 are collected and stored using a Digital Equipment Corporation VAXstation 4000. For each instrument identified in Table 1, a log is maintained and the records are stored for future reference.

Winds were measured at the end of the pier at an elevation of 19 m using a WeatherMeasure Skyvane anemometer. Monthly resultant wind speeds and directions (Figure 4) are determined by vector averaging the data. Wind directions (Table 3) indicate where the wind is coming from. Temperature and atmospheric pressure means (Table 3) are the average of the values presented for the month. Total precipitation is the sum for the month.

The following may be useful for converting the data in Table 3 to other frequently used units of measurement:

1. Millimeters (mm) to inches (in.) -  
 $\text{mm} \times .03937 = \text{in.}$
2. Millibars (mb) to inches of mercury (in. Hg) -  
 $\text{mb} \times 0.02953 = \text{in. Hg}$
3. Degrees Celsius (C) to degrees Fahrenheit (F) -  
 $(\text{C} \times 9/5) + 32 = \text{F}$
4. Meters per second (m/s) to knots (kn) -  
 $\text{m/s} \times 1.943 = \text{kn}$

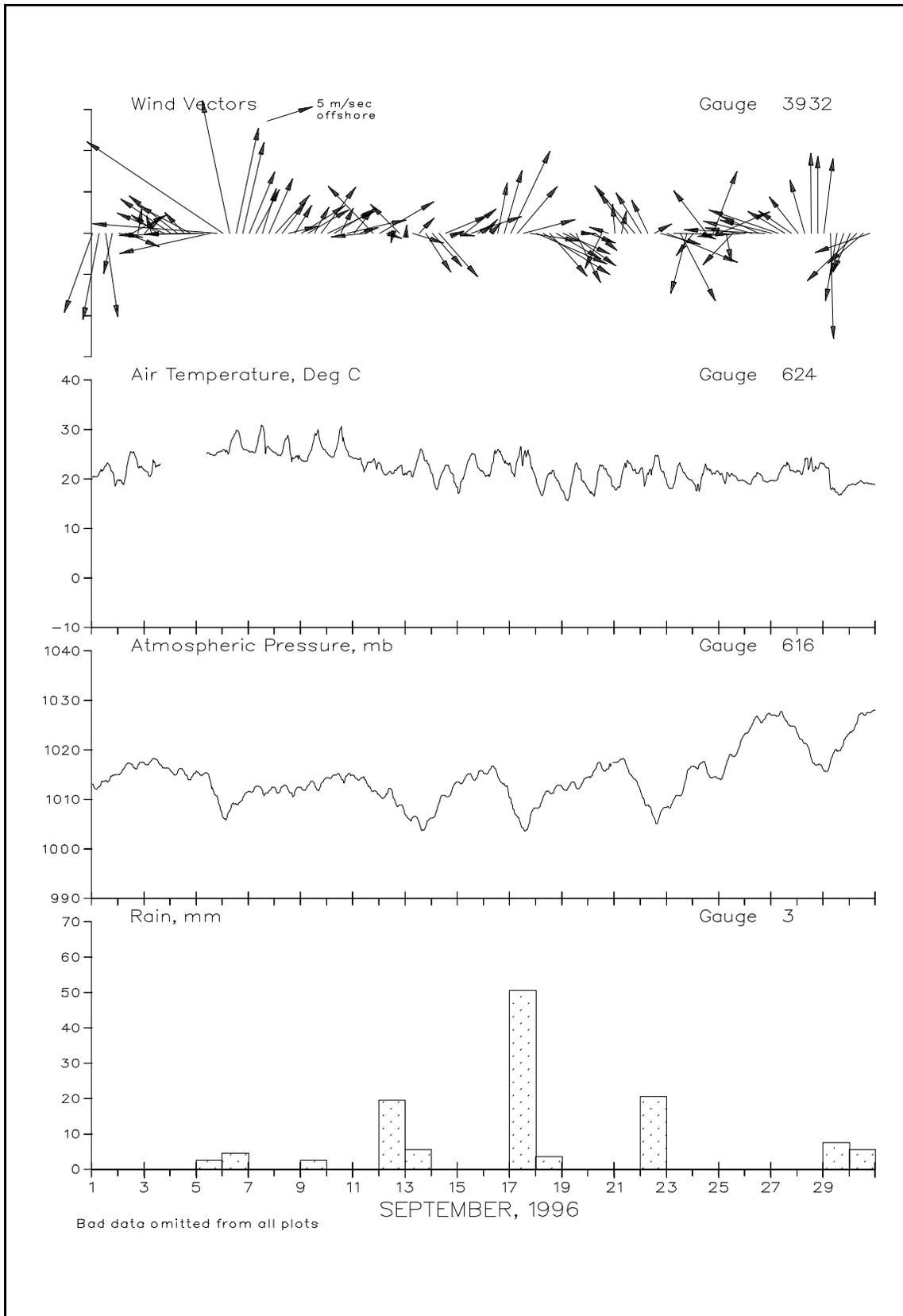


Figure 4. Meteorological Monthly Summary

**Table 3  
Meteorological Data**

Sep 1996						
Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
1	100	10	17	20.5	1013.1	0
	700	11	9	21.1	1012.6	0
	1300	10	352	22.6	1013.9	0
	1900	5	10	21.6	1014.8	0
2	100	2	1	19.9	1015.0	0
	700	4	1	20.3	1016.9	0
	1300	4	238	25.3	1017.1	0
	1900	3	187	22.3	1017.0	0
3	100	2	220	21.7	1017.2	0
	700	2	166	21.2	1018.0	0
	1300	4	127	22.6	1017.9	0
	1900	5	116		1016.3	0
4	100	7	128		1015.7	0
	700	7	131		1015.5	0
	1300	3	141	inoperative	1015.6	0
	1900	6	121		1014.0	0
5	100	5	88		1015.6	0
	700	9	88		1015.2	3
	1300	10	75	25.0	1013.8	0
	1900	13	94	25.3	1010.7	0
6	100	18	127	25.9	1006.4	0
	700	16	169	26.3	1007.8	5
	1300	13	190	29.7	1009.1	0
	1900	11	191	26.2	1010.3	0
7	100	8	199	25.6	1011.7	0
	700	6	204	25.9	1012.7	0
	1300	6	195	30.7	1011.9	0
	1900	7	200	26.3	1011.8	0
8	100	6	218	25.3	1012.2	0
	700	4	213	25.4	1012.6	0
	1300	3	255	28.2	1011.8	0
	1900	4	207	24.3	1011.7	0
9	100	6	233	23.8	1012.4	0
	700	5	236	24.5	1012.9	3
	1300	3	205	28.9	1013.1	0
	1900	7	212	27.0	1013.3	0
10	100	6	241	25.1	1014.5	0
	700	5	235	24.8	1014.9	0
	1300	3	203	30.3	1014.6	0
	1900	6	255	25.7	1015.0	0

**Table 3**  
**Meteorological Data (continued)**

Sep 1996						
Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
11	100	4	215	24.2	1014.9	0
	700	2	249	24.3	1014.2	0
	1300	4	82	22.7	1013.3	0
	1900	7	140	23.9	1011.7	0
12	100	7	235	23.1	1010.8	0
	700	2	292	21.0	1011.2	20
	1300	1	10	21.1	1010.5	0
	1900	5	139	22.5	1009.0	0
13	100	1	184	21.1	1006.8	0
	700	3	1	20.4	1006.4	5
	1300	2	220	25.0	1005.4	0
	1900	5	331	23.7	1004.6	0
14	100	5	322	21.0	1006.3	0
	700	7	322	19.0	1009.2	0
	1300	5	244	22.7	1010.7	0
	1900	2	1	21.2	1012.0	0
15	100	1	247	17.1	1013.6	0
	700	4	228	21.1	1014.2	0
	1300	6	249	24.9	1014.9	0
	1900	2	239	22.4	1014.9	0
16	100	2	219	21.1	1015.3	0
	700	1	219	21.8	1016.4	0
	1300	6	189	25.9	1014.8	0
	1900	8	193	23.5	1013.2	0
17	100	11	202	22.6	1010.2	0
	700	7	216	23.8	1006.6	51
	1300	6	253	24.4	1004.1	0
	1900	5	280	24.4	1006.2	0
18	100	8	1	19.3	1008.3	0
	700	9	1	17.2	1010.5	4
	1300	6	1	21.0	1011.4	0
	1900	6	303	20.1	1012.7	0
19	100	6	297	17.7	1012.3	0
	700	6	309	16.5	1012.8	0
	1300	6	336	23.2	1012.5	0
	1900	1	273	19.7	1013.4	0
20	100	3	1	17.8	1014.6	0
	700	3	312	18.0	1016.2	0
	1300	5	22	22.8	1016.3	0
	1900	2	109	20.8	1016.2	0

**Table 3  
Meteorological Data (concluded)**

Sep 1996						
Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
21	100	3	175	17.9	1017.5	0
	700	3	190	20.5	1018.1	0
	1300	6	148	23.6	1016.2	0
	1900	7	143	21.9	1014.1	0
22	100	6	151	22.3	1011.2	0
	700	4	157	21.3	1008.9	20
	1300	2	238	23.7	1006.2	0
	1900	4	1	22.0	1007.4	0
23	100	8	295	18.9	1008.6	0
	700	6	271	18.9	1010.1	0
	1300	9	335	22.7	1010.8	0
	1900	7	13	20.3	1015.1	0
24	100	3	33	19.3	1016.7	0
	700	2	1	18.2	1017.2	0
	1300	6	146	22.3	1016.3	0
	1900	8	198	21.1	1014.5	0
25	100	6	243	21.0	1014.2	0
	700	3	351	20.1	1017.1	0
	1300	5	38	20.8	1018.8	0
	1900	4	99	19.7	1020.6	0
26	100	5	85	19.5	1023.4	0
	700	5	105	19.8	1025.2	0
	1300	4	117	21.1	1026.4	0
	1900	8	92	19.5	1026.4	0
27	100	6	106	19.8	1027.1	0
	700	8	111	20.6	1026.9	0
	1300	5	124	22.7	1026.3	0
	1900	4	127	21.7	1024.9	0
28	100	5	145	21.7	1023.2	0
	700	7	166	23.0	1021.4	0
	1300	10	179	24.4	1018.3	0
	1900	9	180	22.1	1017.0	0
29	100	9	185	23.2	1015.8	0
	700	13	358	18.2	1017.7	7
	1300	8	8	17.4	1019.7	0
	1900	5	15	17.5	1021.5	0
30	100	5	21	18.8	1023.7	0
	700	8	41	19.1	1025.4	6
	1300	5	45	19.3	1027.4	0
	1900	6	67	19.1	1027.6	0
		Resultant		Mean	Mean	Total
		1	174	22.2	1014.6	124

# Wave Data

## 3

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Wave data are collected from three different sets of instruments, as shown in Table 1 and Figure 3. The first is an array of fifteen pressure gauges, collectively referred to as gauge 3111 (gauge 111 being one of them). Directional information is computed from these gauges using an iterative maximum likelihood estimator. The second is a Baylor staff gauge (625) and a pressure gauge (641), both attached to the pier. The third is a Waverider buoy (630). The data are collected, analyzed, and stored on optical disc using a Digital Equipment Corporation VAXstation 4000. Data is sampled at 2 hertz, with five contiguous 34 minute records, for a total collection period of nearly 2 hours and 51 minutes. This report reflects the data collection periods of 0100, 0700, 1300, and 1900 EST. The results are based only on the first 34 minute record. The exception is the 8 Meter Array (3111) which condenses the first four records into one statistical value.

Wave height  $H_{mo}$  is an energy-based statistic equal to four times the standard deviation of the sea surface elevations. Wave height reported from the pressure gauge has been compensated for hydrodynamic attenuation using linear wave theory. Wave period is identified from the computation of a variance (energy) spectrum with 60 degrees of freedom calculated from a 34-min record. Peak wave period  $T_p$  is defined as the period associated with the maximum energy in the spectrum.

Table 4 presents the wave heights and periods for each wave record obtained at 6 hr intervals during the month. The monthly means and standard deviations from the means shown in Table 4 are average values computed from this data. Figure 5 is a time history of all  $H_{mo}$  and  $T_p$  values obtained for all gauges.

Differences in wave periods between wave gauges (Table 4 and Figure 5) may be the result of wave breaking, wave reformation, the presence of multiple wave trains containing nearly equal energy, and statistical variations in spectral estimations.

**Table 4  
Wave Data**

Sep 1996										
Day	Hour	641 Pressure Gauge		625 Baylor Gauge		3111 8 Meter Array			630 Waverider	
		Hmo,m	Tp,sec	Hmo,m	Tp,sec	Hmo,m	Tp,sec	Dir,TN	Hmo,m	Tp,sec
1	0100	0.48	6.1	0.73	7.2	2.47	13.6	92	0.87	7.6
	0700	1.39	14.3	2.51	14.3	2.87	13.6	94	3.10	12.2
	1300	1.28	13.5	2.99	13.5	3.10	13.6	92	3.34	14.3
	1900	1.24	14.3	3.34	14.3	3.46	13.6	82	3.43	14.3
2	0100	1.57	11.7	2.21	11.7	2.09	13.6	76	2.14	11.2
	0700	1.30	12.2	1.61	12.9	1.73	12.0	62	1.75	12.2
	1300	1.00	11.7	1.45	11.2	1.53	12.0	52	1.59	11.2
	1900	0.93	10.3	1.37	11.2	1.43	10.8	58	1.53	10.7
3	0100	0.86	11.7	1.27	10.7	1.24	10.8	54	1.34	11.2
	0700	0.88	8.9	1.05	9.5	1.10	9.8	74	1.26	9.2
	1300	0.92	11.7	1.13	11.7	1.25	9.8	60	1.34	11.2
	1900	0.83	12.2	1.11	12.2	1.14	12.0	102	1.25	11.7
4	0100	0.95	11.2	1.15	11.2	1.11	10.8	100	1.32	10.7
	0700	0.89	12.2	1.17	12.2	1.11	12.0	106	1.27	11.2
	1300	1.08	13.5	1.18	13.5	1.19	12.0	68	1.33	13.5
	1900	0.90	12.2	1.01	12.2	1.04	13.6	102	1.22	9.9
5	0100	1.13	14.3	1.25	14.3	1.33	13.6	100	1.50	14.3
	0700	1.19	13.5	1.64	13.5	1.75	13.6	102	1.84	13.5
	1300	1.46	14.3	1.93	14.3	1.91	13.6	100	2.10	13.5
	1900	1.32	14.3	2.12	8.6	2.30	8.2	84	2.46	8.1
6	0100	1.66	9.2	2.69	8.9	3.11	8.9	80	3.29	8.6
	0700	1.25	9.2	1.96	8.9	1.96	8.9	78	2.48	7.8
	1300	1.25	7.6	1.38	8.9	1.39	8.2	68	1.79	8.3
	1900	0.92	8.1	1.07	9.5	1.09	8.9	78	1.43	8.9
7	0100	0.78	8.1	0.91	9.5	0.92	8.9	74	1.14	9.2
	0700	0.53	6.5	0.68	9.5	0.70	8.9	78	0.84	8.6
	1300	0.57	5.9	0.65	9.2	0.68	8.9	72	0.85	9.2
	1900	0.48	8.3	0.58	9.5	0.59	8.9	60	0.74	9.2
8	0100	0.40	7.4	0.55	9.2	0.58	8.9	74	0.67	8.9
	0700	0.41	8.9	0.49	8.9	0.52	9.8	68	0.60	8.9
	1300	0.42	10.3	0.49	10.3	0.55	8.9	74	0.64	8.6
	1900	0.38	9.9	0.47	9.9	0.49	10.8	102	0.59	11.2
9	0100	0.38	10.7	0.47	11.2	0.50	10.8	106	0.57	10.7
	0700	0.34	10.3	0.40	10.7	0.44	10.8	78	0.54	10.7
	1300	0.39	9.5	0.43	9.5	0.46	9.8	78	0.51	9.2
	1900	0.38	8.9	0.43	9.9	0.44	9.8	106	0.58	10.3
10	0100	0.31	9.5	0.38	9.9	0.39	9.8	104	0.44	9.5
	0700	0.29	9.9	0.35	9.5	0.38	9.8	104	0.44	9.5
	1300	0.29	8.6	0.37	8.6	0.40	8.9	100	0.44	8.6
	1900	0.34	8.9	0.38	9.5	0.38	8.9	104	0.49	8.6

**Table 4  
Wave Data (continued)**

Sep 1996										
Day	Hour	641 Pressure Gauge		625 Baylor Gauge		3111 8 Meter Array			630 Waverider	
		Hmo,m	Tp,sec	Hmo,m	Tp,sec	Hmo,m	Tp,sec	Dir,TN	Hmo,m	Tp,sec
11	0100	0.23	9.2	0.35	9.2	0.37	8.9	102	0.41	9.5
	0700	0.28	13.5	0.33	8.9	0.34	13.6	60	0.38	9.2
	1300	0.23	13.5	0.32	12.9	0.35	13.6	84	0.40	9.2
	1900	0.39	9.5	0.54	2.8	0.41	13.6	102	0.60	8.1
12	0100	0.35	4.5	0.50	13.5	0.42	13.6	86	0.60	4.2
	0700	0.33	9.5	0.37	13.5	0.38	13.6	66	0.45	8.9
	1300	0.32	6.6	0.39	12.9	0.42	13.6	102	0.50	8.3
	1900	0.36	11.7	0.41	11.7	0.44	12.0	100	0.45	12.2
13	0100	0.43	12.2	0.50	12.2	0.55	12.0	78	0.55	11.7
	0700	0.64	11.2	0.67	13.5	0.75	13.6	102	0.86	9.9
	1300	0.63	15.1	0.73	13.5	0.81	13.6	100	0.86	12.9
	1900	0.87	13.5	0.88	13.5	0.83	13.6	102	0.95	12.9
14	0100	0.76	15.1	0.92	15.1	0.99	15.7	100	1.24	15.1
	0700	0.93	13.5	1.13	14.3	1.20	13.6	98	1.28	14.3
	1300	0.72	12.9	0.92	12.9	0.94	12.0	98	1.15	12.9
	1900	0.62	13.5	0.79	12.9	0.81	13.6	90	0.87	12.2
15	0100	0.43	11.2	0.62	11.2	0.70	10.8	68	0.72	10.7
	0700	0.50	9.5	0.61	9.2	0.67	10.8	102	0.74	10.7
	1300	0.38	8.6	0.57	10.7	0.63	8.9	80	0.67	10.7
	1900	0.54	8.6	0.62	10.3	0.69	8.9	90	0.75	8.9
16	0100	0.41	10.3	0.59	9.9	0.66	10.8	72	0.68	10.3
	0700	0.52	10.3	0.67	9.9	0.72	9.8	64	0.78	8.9
	1300	0.40	9.5	0.60	11.2	0.69	9.8	68	0.75	11.2
	1900	0.55	10.7	0.81	10.7	0.71	9.8	68	0.99	10.3
17	0100	0.52	10.3	0.70	10.7	0.73	9.8	66	0.94	10.3
	0700	0.55	10.3	0.56	10.3	0.66	9.8	106	0.76	10.3
	1300	0.46	8.6	0.51	9.2	0.52	8.9	106	0.63	8.6
	1900	0.50	7.8	0.48	9.9	0.51	9.8	74	0.62	10.7
18	0100	0.56	5.6	0.77	5.3	0.77	5.3	26	1.02	5.5
	0700	0.44	5.3	0.65	5.0	0.63	5.0	20	0.91	5.3
	1300	0.65	5.6	0.80	5.5	0.88	5.6	26	1.13	5.3
	1900	0.63	6.0	0.89	6.6	0.93	7.1	48	1.19	7.4
19	0100	0.70	7.4	0.83	7.4	0.85	7.6	52	1.06	7.6
	0700	0.61	7.4	0.86	7.4	0.94	7.6	54	1.06	7.4
	1300	0.59	7.2	0.76	6.8	0.78	6.6	50	0.86	6.8
	1900	0.46	5.7	0.75	13.5	0.74	13.6	84	0.81	5.9
20	0100	0.50	12.9	0.69	12.9	0.73	13.6	84	0.87	13.5
	0700	0.37	12.9	0.63	12.9	0.64	13.6	84	0.68	12.9
	1300	0.41	12.2	0.61	12.9	0.61	13.6	82	0.70	12.9
	1900	0.37	12.9	0.61	12.9	0.65	12.0	76	0.70	12.2

**Table 4**  
**Wave Data (concluded)**

Sep 1996										
Day	Hour	641 Pressure Gauge		625 Baylor Gauge		3111 8 Meter Array			630 Waverider	
		Hmo,m	Tp,sec	Hmo,m	Tp,sec	Hmo,m	Tp,sec	Dir,TN	Hmo,m	Tp,sec
21	0100	0.43	12.2	0.64	12.2	0.63	12.0	74	0.71	12.2
	0700	0.28	12.9	0.55	12.2	0.60	12.0	98	0.58	11.7
	1300	0.42	12.2	0.58	12.9	0.58	12.0	96	0.61	12.2
	1900	0.41	12.9	0.67	12.9	0.60	12.0	100	0.73	12.9
22	0100	0.47	12.2	0.65	12.2	0.57	12.0	98	0.66	12.2
	0700	0.33	12.9	0.56	12.2	0.55	12.0	80	0.53	11.7
	1300	0.44	12.2	0.53	12.2	0.58	12.0	94	0.62	12.2
	1900	0.29	12.2	0.47	12.2	0.51	12.0	80	0.58	12.2
23	0100	0.33	11.7	0.46	11.7	0.49	12.0	88	0.70	11.7
	0700	0.29	12.2	0.49	12.2	0.44	12.0	62	0.69	12.2
	1300	0.35	3.8	0.61	3.8	0.75	5.0	22	1.09	3.9
	1900	0.60	5.6	0.89	5.3	0.87	5.6	28	1.09	5.1
24	0100	0.55	5.2	0.81	4.8	0.77	5.0	38	0.91	5.0
	0700	0.38	5.2	0.50	12.9	0.48	13.6	82	0.58	5.2
	1300	0.29	12.2	0.44	11.7	0.41	12.0	70	0.50	12.9
	1900	0.34	12.2	0.51	11.7	0.44	12.0	74	0.61	12.9
25	0100	0.26	14.3	0.44	12.2	0.46	12.0	66	0.52	15.1
	0700	0.37	15.1	0.53	15.1	0.57	10.8	62	0.62	11.2
	1300	0.51	5.2	0.85	10.7	0.88	12.0	60	1.02	10.7
	1900	0.54	10.7	0.77	10.7	0.74	12.0	92	0.86	11.2
26	0100	0.37	12.2	0.69	10.7	0.72	10.8	62	0.80	11.2
	0700	0.53	14.3	0.80	11.2	0.76	13.6	96	0.85	11.2
	1300	0.42	14.3	0.70	10.3	0.72	10.8	60	0.90	11.2
	1900	0.58	10.7	0.87	10.7	0.78	10.8	56	0.95	9.9
27	0100	0.62	4.8	0.90	13.5	0.83	13.6	84	0.98	4.6
	0700	0.76	4.8	1.00	4.5	0.91	4.6	92	1.10	4.7
	1300	0.51	4.7	0.75	4.8	0.72	4.6	62	0.86	4.6
	1900	0.55	5.5	0.71	5.1	0.69	13.6	90	0.81	5.0
28	0100	0.52	5.7	0.69	5.9	0.75	6.2	102	0.88	6.0
	0700	0.80	5.9	0.80	7.2	0.82	6.6	108	0.95	7.2
	1300	0.86	7.0	0.94	7.0	0.96	7.1	106	1.20	7.0
	1900	0.97	6.6	1.03	7.0	1.01	7.1	84	1.25	7.2
29	0100	0.72	7.0	0.83	7.2	0.84	7.1	76	1.04	7.4
	0700	0.80	6.3	1.00	7.2	1.14	6.2	30	1.21	3.7
	1300	0.84	6.0	1.29	6.0	1.25	5.9	42	1.59	5.9
	1900	0.83	5.9	1.02	5.9	1.02	5.9	30	1.23	5.9
30	0100	0.50	5.9	0.75	5.6	0.72	7.1	106	0.91	6.6
	0700	0.59	6.8	0.85	3.9	0.85	7.1	104	1.01	3.8
	1300	0.59	6.6	0.87	4.5	0.83	7.1	104	1.00	6.8
	1900	0.55	6.8	0.81	4.2	0.74	4.2	36	0.91	4.4
	Mean	0.62	9.9	0.85	10.2	0.89	10.4	78	1.01	9.7
	Std dev	0.31	3.0	0.53	2.9	0.58	2.7	21	0.59	2.8

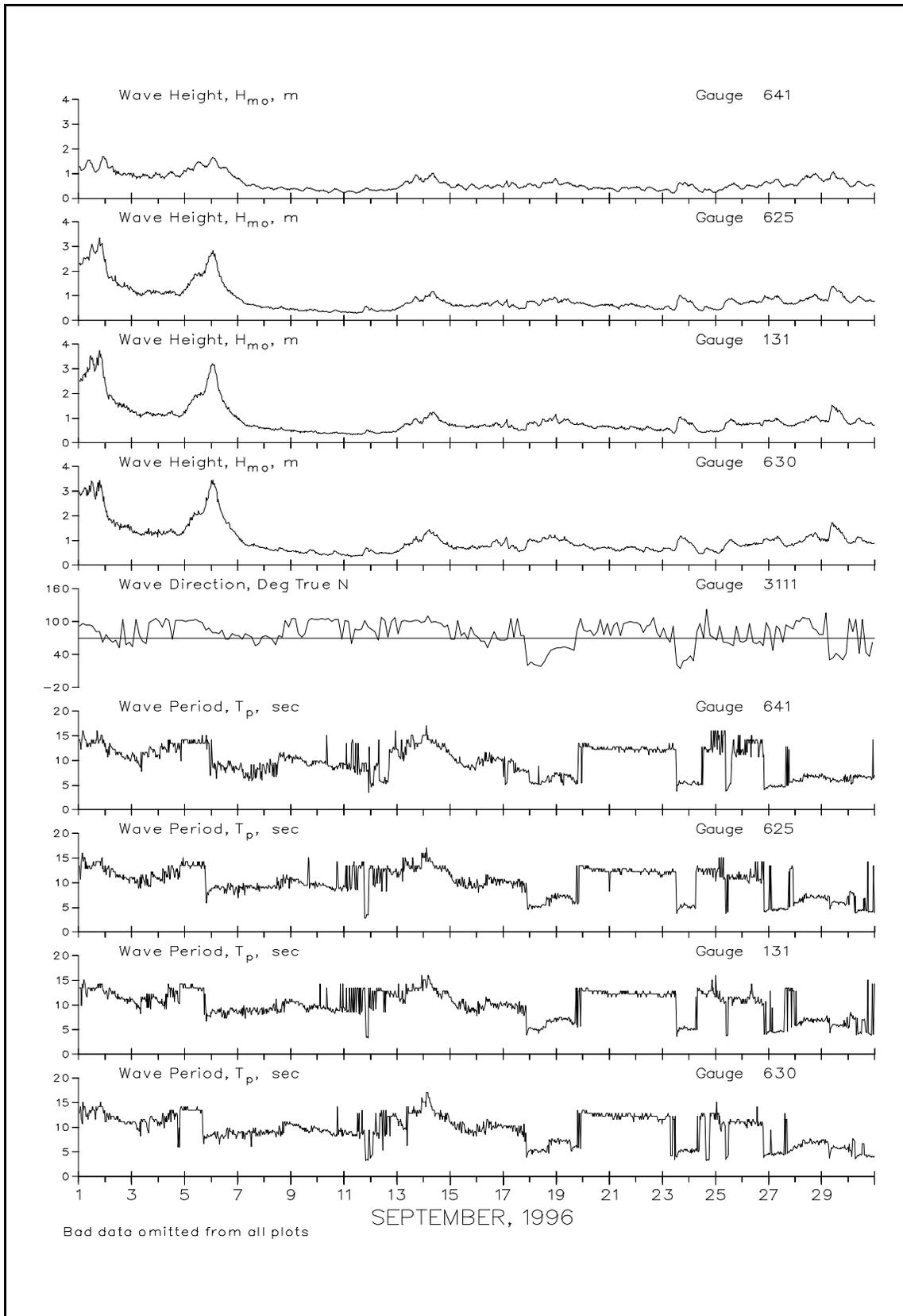


Figure 5. Wave Heights and Periods

# Current Data

## 4

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Current data (Table 5) are collected from a Marsh-McBirney electromagnetic biaxial current meter and by visually observing the movement of small drogues on the water surface in the surf and at the seaward end of the pier, as well as 500 m updrift of the pier, approximately 12 m offshore (Table 6).

Since the shoreline orientation is approximately N20W, longshore currents flow either toward 340 deg (i.e. northward) or toward 160 deg (i.e. southward). Similarly, cross-shore currents are either onshore (westward) or offshore (eastward). All current speeds are given in centimeters per second (cm/sec). Resultant speeds and directions are determined by vector averaging the cross-shore and longshore data. Current directions indicate the direction that the current is moving towards. Current data are plotted in Figure 2.

**Table 5**  
**Current Meter Data - Gauge 3539**

SEPTEMBER 1996

Cross Long					Cross Long					Cross Long							
Day	Time	Shore	Shore	Speed	Dir	Day	Time	Shore	Shore	Speed	Dir	Day	Time	Shore	Shore	Speed	Dir
1	100	8	27	28	177	11	100	0	3	3	154	21	100	-4	9	11	131
	700	9	19	21	185		700	-1	4	4	135		700	-3	7	8	131
	1300	6	23	23	174		1300	-2	-2	5	22		1300	-2	1	3	94
	1900	4	2	4	227		1900	-3	4	6	117		1900	-2	0	3	46
2	100	4	9	10	185	12	100	4	-1	4	278	22	100	-3	-6	8	12
	700	-8	7	12	110		700	-4	3	6	102		700	-4	-2	6	36
	1300	1	15	15	164		1300	-6	8	11	120		1300	0	-19	20	339
	1900	3	7	8	183		1900	-3	3	4	106		1900	-2	-2	4	31
3	100	13	4	14	233	13	100	0	7	7	159	23	100	-5	-5	9	27
	700	4	0	4	251		700	-1	18	18	155		700	-3	7	8	131
	1300	inoperative					1300	3	4	5	201		1300	-6	1	7	80
	1900	1	-4	5	325		1900	2	0	2	269		1900	-7	18	20	137
4	100	-2	3	5	112	14	100	-2	25	25	154	24	100	-7	19	20	138
	700	4	1	4	242		700	-3	16	17	147		700	-10	34	36	142
	1300	-2	-1	4	42		1300	5	18	18	176		1300	-5	12	13	133
	1900	-4	-6	9	15		1900	0	28	28	158		1900	0	0	0	
5	100	-3	-3	6	31	15	100	-4	12	13	139	25	100	0	-2	3	347
	700	-3	-11	12	359		700	-3	2	5	90		700	-3	2	4	100
	1300	2	-21	22	334		1300	5	-9	11	312		1300				
	1900	1	-8	9	336		1900	0	-8	9	339		1900				
6	100	-3	-51	52	344	16	100	-7	6	9	107	26	100	inoperative			
	700	-2	-63	64	342		700	-1	10	10	147		700				
	1300	4	-50	51	335		1300	9	4	10	224		1300	-4	-14	16	358
	1900	12	-21	25	311		1900	-1	-6	7	354		1900	-7	-4	10	36
7	100	1	-12	13	336	17	100	0	-1	2	354	27	100	-3	-7	9	10
	700	0	-4	5	354		700	0	-8	9	349		700	-5	-11	14	6
	1300	1	-10	11	337		1300	1	-1	2	313		1300	0	-5	6	336
	1900	-1	-8	10	354		1900	-4	-1	5	51		1900	-2	-2	4	20
8	100	-1	0	2	75	18	100	-2	0	3	62	28	100	inoperative			
	700	-4	3	6	99		700	-2	-3	5	18		700	-3	-2	5	30
	1300	8	-14	17	312		1300	-13	23	27	128		1300	-2	-2	4	26
	1900	-5	0	6	69		1900	-6	19	20	139		1900	-5	-20	22	357
9	100	-3	0	4	65	19	100	-9	32	33	143	29	100	inoperative			
	700	-3	4	6	110		700	-6	20	21	141		700	-3	-5	7	17
	1300	0	-24	25	339		1300	-10	25	28	137		1300	-6	24	24	144
	1900	-2	1	4	89		1900	-9	16	18	128		1900	-3	11	12	141
10	100	-3	0	4	61	20	100	-7	6	10	108	30	100	inoperative			
	700	-1	4	4	139		700	-7	21	22	138		700	-3	6	7	128
	1300	3	-13	15	327		1300	-7	14	16	132		1300	-6	14	15	133
	1900	-3	1	4	83		1900	-3	13	14	143		1900	-4	11	12	136

KEY:

+cross-shore = offshore, cm/sec  
 -cross-shore = onshore, cm/sec  
 +longshore = south, cm/sec  
 -longshore = north, cm/sec  
 Speed = Resultant speed, cm/sec  
 Dir = Resultant direction, degrees true north

**Table 6**  
**Visually Observed Current Data**

Sep 1996												
Day	Pier End				Mid-Surf Zone				Beach			
	Cross Shore	Long Shore	Speed	Dir	Cross Shore	Long Shore	Speed	Dir	Location	Speed	Dir	
1	0	27	27	160	0	-102	102	340	North	4	N	
2	-4	22	22	171	23	30	38	123	North	28	S	
3	6	-19	20	357	-14	-47	49	323	South	11	N	
4	3	-18	18	349	-8	-30	31	326	South	52	N	
5	-5	-10	12	313	-23	-47	52	313	South	58	N	
6	0	-152	152	340	0	-87	87	340	South	59	N	
7	14	-19	24	17	0	-51	51	340	South	40	N	
8	9	-36	37	354	14	-55	57	354	South	14	N	
9	6	-14	16	4	8	-11	14	17	South	56	N	
10	14	-14	20	25	4	-15	16	354	South	40	N	
11	0	-20	20	340	4	-5	7	17	South	26	N	
12	4	21	21	149	3	6	7	70	South	17	N	
13	6	29	30	149	3	10	10	70	South	50	N	
14	0	61	61	160	0	0	0		no observation			
15	8	-6	10	31	0	-7	7	340	South	49	N	
16	1	-7	7	346	7	-47	47	349	South	6	N	
17	14	-36	39	2	6	-38	39	349	no observation			
18	0	34	34	160	-10	41	42	174	North	41	S	
19	0	51	51	160	-14	55	57	174	no observation			
20	0	47	47	160	0	0	0		North	5	S	
21	6	-6	9	25	12	-47	48	354	South	0		
22	16	-27	31	11	-10	-16	19	309	South	32	N	
23	9	12	16	123	-4	16	17	174	North	37	S	
24	-7	68	68	166	-4	12	13	179	North	44	S	
25	2	12	13	149	2	10	10	146	North	6	S	
26	3	-12	13	354	0	-10	10	340	South	38	N	
27	-9	-29	30	323	-2	-4	4	309	South	46	N	
28	-3	-30	31	334	6	-38	39	349	South	35	N	
29	-5	47	47	166	-6	55	56	166	North	76	S	
30	-12	23	26	187	-38	15	41	228	North	36	S	

KEY:  
+cross-shore = offshore, cm/sec  
-cross-shore = onshore, cm/sec  
+longshore = south, cm/sec  
-longshore = north, cm/sec  
Speed = Resultant speed, cm/sec  
Dir = Resultant direction, degrees true north

# Visual Observations

## 5

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Visual wave direction measurements (Table 7) of both the primary wave train (i.e. that having the higher wave heights) and the secondary wave train (which must be clearly distinguishable as a wave train separate from the primary waves but not surface chop or capillary waves) are taken daily at the seaward end of the pier. The pier axis (considered perpendicular to the beach at the FRF) is oriented 70 deg east of true north; consequently, wave angles greater than 70 deg indicate that the waves were coming from the south side of the pier.

The width of the surf zone (seawardmost breaker position to shoreline) is determined from the pier deck.

Measurements of surface water temperature, density, and depth of visibility are also taken daily at the seaward end of the pier. A Bucket Thermometer is lowered about 0.3 m into the water and allowed to remain for at least one minute. The temperature is then read, and a hydrometer is used to determine the density. A Secchi disc is used to determine the depth of visibility.

**Table 7**  
**Visual Observations**

Sep 1996							
Day	Time	Wave Approach Angle at Pier End deg from True N		Width of Surf Zone,m	Water Characteristics at Pier End		
		Primary	Secondary		Temp.,C	Density g/cc	Secchi Vis.,m
1	0745	90	40	475	25.0	1.0190	0.3
2	0628	70		341	25.0	1.0192	0.3
3	0713	80		101	25.0	1.0190	0.3
4	0705	90	110	180	24.4	1.0194	0.6
5	0630	90	70	232	24.4	1.0202	0.6
6	0620	100		344	25.9	1.0200	0.3
7	0815	100	110	87	21.9	1.0220	0.6
8	0815	90	130	66	23.9	1.0212	1.5
9	0545	110		58	23.6	1.0213	1.2
10	0550	110		47	23.3	1.0216	1.5
11	0800	115		44	24.4	1.0209	3.4
12	0635	95	20	38	24.2	1.0204	3.4
13	0630	90	60	66	24.2	1.0202	3.0
14	0830	40	100	69	24.7	1.0178	1.5
15	0815	85	115	66	24.2	1.0172	1.8
16	0550	80		61	24.4	1.0181	3.0
17	0605	100		67	23.9	1.0208	1.2
18	0600	30		58	22.8	1.0215	4.6
19	0615	40		98	22.2	1.0200	1.8
20	0600	70	50	69	22.5	1.0181	2.7
21	0810	70	120	53	23.1	1.0187	2.7
22	0845	90	120	49	23.1	1.0199	1.5
23	0610	25		43	22.5	1.0212	0.6
24	0630	50	80	52	21.9	1.0196	2.4
25	0600	70	20	24	22.2	1.0203	1.8
26	0720	50		61	22.2	1.0207	2.1
27	0630	100		49	22.2	1.0208	2.1
28	0910	120	75	61	22.2	1.0215	1.2
29	0930	30		85	21.7	1.0221	0.9
30	0645	50		52	21.1	1.0220	0.9

# Water Levels

## 6

Since 1978, the National Oceanic and Atmospheric Administration (NOAA)/National Ocean Service (NOS) has operated a primary tide station (No. 865-1370) at the seaward end of the FRF pier. A NOS acoustic tide gauge (Next Generation Water Level Measurement System, NGWLMS) is used to collect water level data every 6 minutes throughout the month.

The variation in water level during the month is shown in Figure 6 along with a list of means and extreme values. This presentation is useful in identifying effects of both meteorological and astronomical forces on the open coast water level. Table 8 contains the range, high, low, and mean water level for each 12.42-hr tidal cycle.

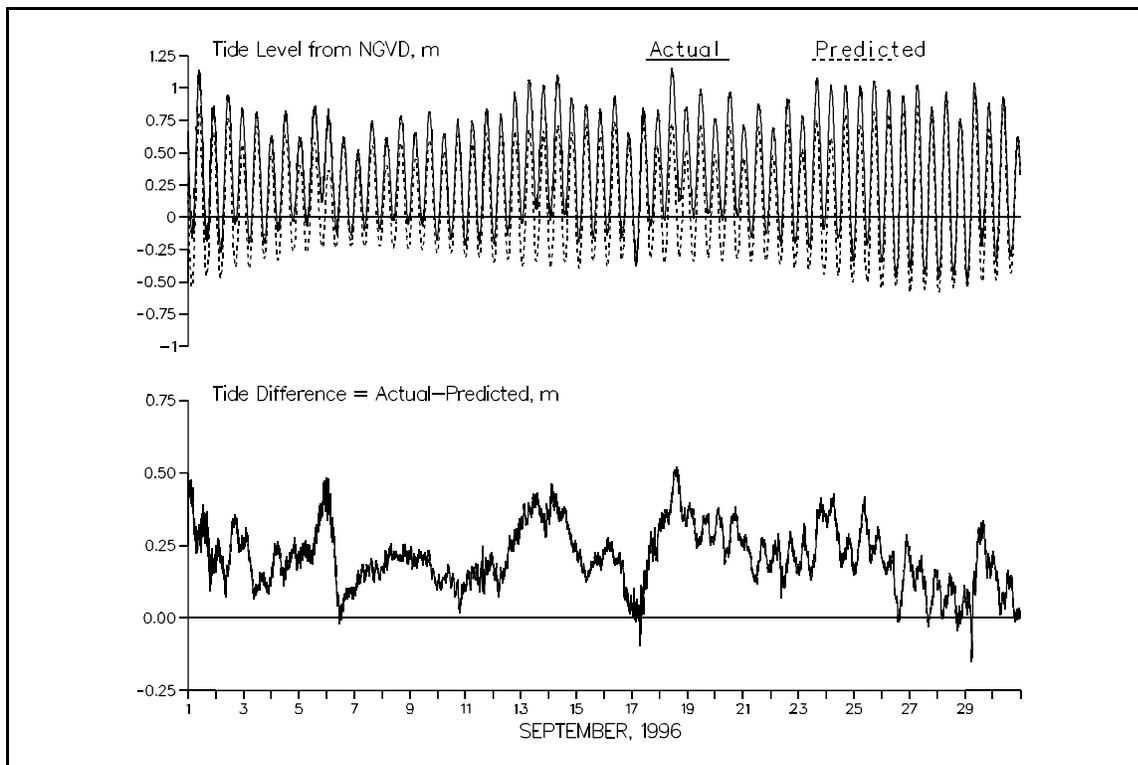


Figure 6. Water Level Variation

**Table 8**  
**Water Levels, m NGVD**

SEP 1996 Tide Levels															
Day	High		Day	Low		Mean	Range	Day	High		Day	Low		Mean	Range
	Time	m		Time	m				Time	m		Time	m		
1	0948	1.14	1	0336	-0.16	0.47	1.30	16	0918	0.94	16	0254	-0.14	0.40	1.08
1	2212	0.86	1	1612	-0.19	0.33	1.05	16	2106	0.66	16	1454	-0.16	0.23	0.82
2	1048	0.95	2	0354	-0.27	0.35	1.22	17	0948	0.84	17	0342	-0.38	0.24	1.22
2	2312	0.85	2	1700	-0.05	0.37	0.90	17	2230	0.83	17	1548	-0.07	0.38	0.90
3	1142	0.82	3	0512	-0.20	0.30	1.02	18	1036	1.16	18	0412	-0.03	0.57	1.18
4	0024	0.63	3	1812	-0.20	0.22	0.84	18	2306	0.86	18	1648	0.12	0.49	0.74
4	1248	0.83	4	0536	-0.11	0.35	0.94	19	1142	0.99	19	0530	-0.01	0.49	1.01
5	0018	0.63	4	1936	-0.04	0.30	0.66	20	0012	0.77	19	1824	0.03	0.40	0.74
5	1418	0.87	5	0724	-0.07	0.41	0.94	20	1248	0.97	20	0624	-0.03	0.46	1.00
6	0142	0.84	5	2000	0.12	0.46	0.73	21	0042	0.72	20	1948	0.00	0.36	0.72
6	1448	0.62	6	0854	-0.14	0.25	0.76	21	1312	0.88	21	0736	-0.16	0.37	1.03
7	0330	0.53	6	2124	-0.14	0.19	0.66	22	0218	0.69	21	2006	-0.13	0.29	0.83
7	1512	0.75	7	0842	-0.11	0.33	0.86	22	1448	0.92	22	0918	-0.22	0.37	1.14
8	0330	0.62	7	2224	-0.09	0.28	0.71	23	0312	0.79	22	2106	-0.20	0.29	0.99
8	1636	0.79	8	0924	-0.03	0.38	0.82	23	1636	1.08	23	0942	-0.24	0.42	1.32
9	0442	0.66	8	2306	-0.06	0.31	0.72	24	0430	1.02	23	2136	-0.10	0.46	1.12
9	1648	0.82	9	1054	-0.07	0.36	0.88	24	1630	1.02	24	1006	-0.17	0.41	1.19
10	0530	0.65	9	2342	-0.18	0.24	0.83	25	0530	1.01	24	2306	-0.34	0.36	1.35
10	1742	0.76	10	1136	-0.17	0.27	0.94	25	1730	1.06	25	1118	-0.21	0.43	1.27
11	0600	0.75	11	0030	-0.21	0.26	0.96	26	0554	0.99	25	2354	-0.35	0.33	1.34
11	1818	0.84	11	1212	-0.22	0.33	1.05	26	1848	0.94	26	1224	-0.47	0.24	1.42
12	0648	0.80	12	0106	-0.21	0.29	1.01	27	0636	1.02	27	0106	-0.41	0.32	1.43
12	1842	0.97	12	1242	-0.14	0.42	1.11	27	1918	0.86	27	1324	-0.44	0.20	1.30
13	0700	1.07	13	0100	-0.06	0.51	1.12	28	0736	0.97	28	0118	-0.48	0.24	1.45
13	1924	1.03	13	1330	0.06	0.53	0.97	28	2012	0.76	28	1400	-0.45	0.15	1.21
14	0736	1.10	14	0142	-0.02	0.55	1.13	29	0812	1.04	29	0148	-0.53	0.27	1.57
14	1954	0.93	14	1354	0.01	0.46	0.91	29	2048	0.89	29	1454	-0.23	0.33	1.11
15	0836	0.87	15	0206	-0.19	0.35	1.07	30	0924	0.93	30	0300	-0.35	0.28	1.28
15	2030	0.84	15	1430	-0.17	0.34	1.00								

# Bathymetry

## 7

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A. Nearshore Profiles. In order to document profile response away from the pier, surveys of four profile lines extending 900 to 1,000 m from shore and located 489 and 581 m north and 517 and 608 m south of the FRF pier are conducted bi-weekly, after storms, and during more complete bathymetric surveys.

These profiles are obtained using either a Trimble 4000 GPS or a Geodimeter 140-T self-tracking total station for positioning, in combination with the Coastal Research Amphibious Buggy (CRAB), a 10.7 m high, self-powered, mobile tripod on wheels.

Figure 7 shows the last survey in August 1996 and the survey(s) in September 1996 on profile line 188, located 517 m south of the pier.

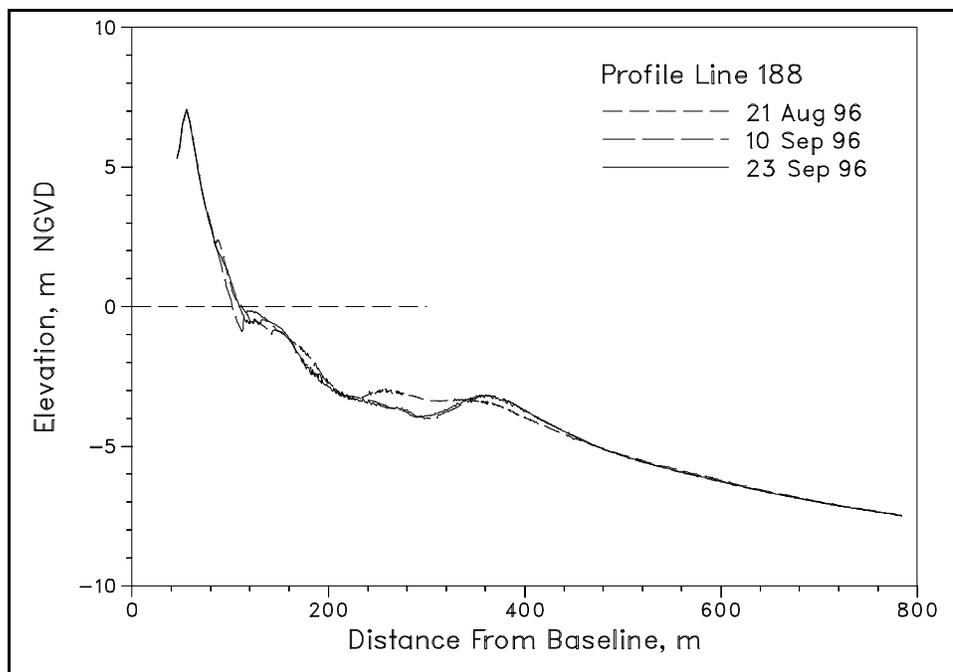


Figure 7. Monthly CRAB Profiles on Profile Line 188.

The profile envelope (Figure 8) reflects the maximum changes that occurred on the profile during 1996. Cross-hatched areas indicate changes to the annual envelope which occurred in September.

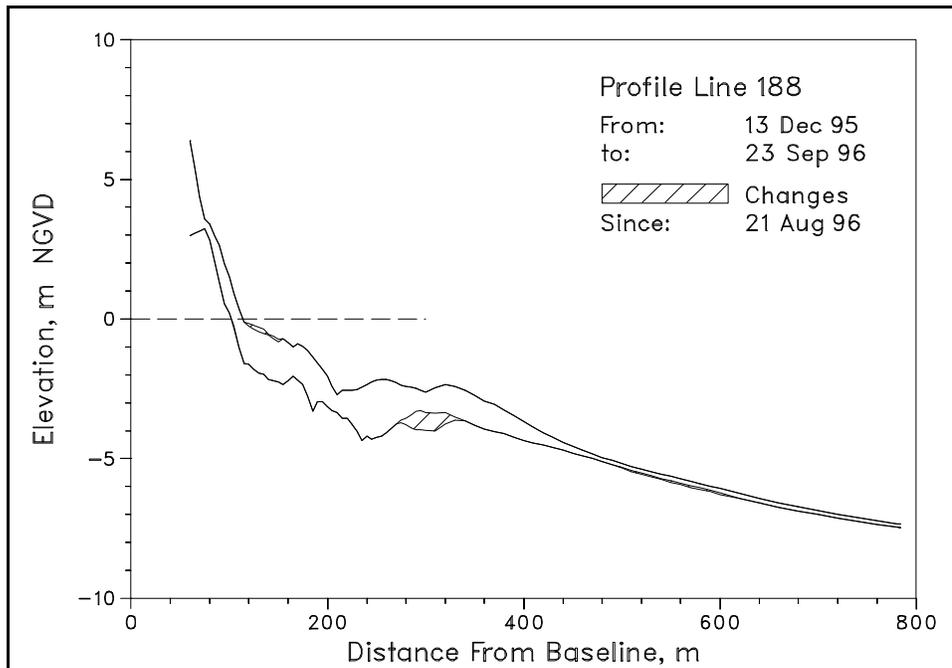
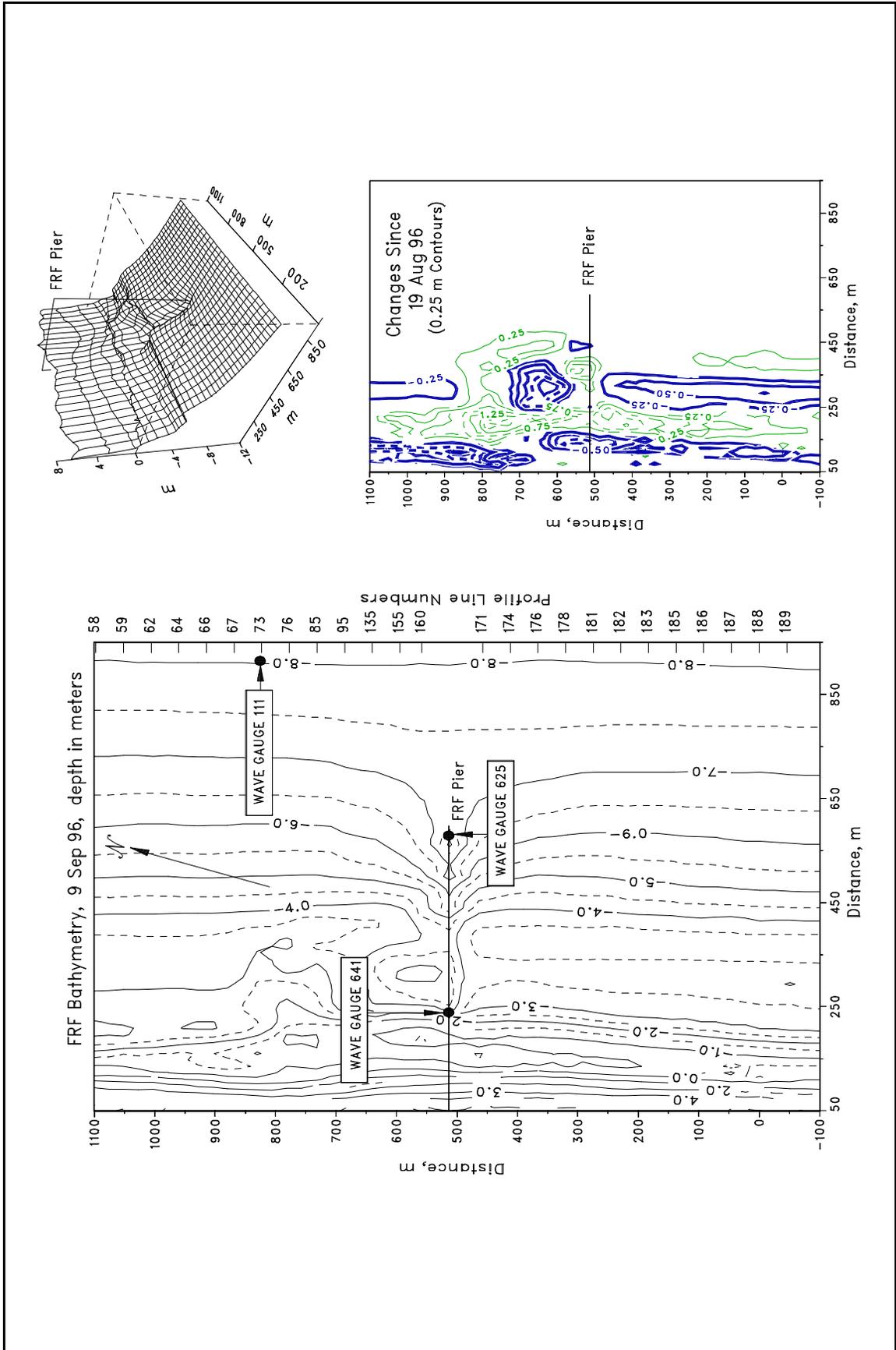


Figure 8. Profile Envelope - Profile Line 188.

B. Bathymetry. Figure 9 includes a two- and three-dimensional contour map and a change plot derived from the bathymetric survey on 9 September. Wide contour lines on the change diagram represent eroded areas; thin lines indicate deposition.



# Special Events

## 8

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A. Storm Data Collection. The following list identifies times when the wave height  $H_{mo}$  at the seaward end of the pier exceeded 2 m.

<u>Start</u>	<u>End</u>
31 Aug (1034)	2 Sep (0242)
5 Sep (0000)	6 Sep (1142)

B. Storm Synopsis.

31Aug-02Sep Northeasterly winds were funneled between hurricane Eduoard (400km offshore) and a high pressure system to the north. Maximum onshore winds (NE) reached 12 m/s at 1634 EST on 31 August. The maximum  $H_{mo}$ , at gauge 630, reached 3.4 m ( $T_p=13.5$  s) at 1142 EST on 1 September. There was no precipitation.

5-6 Sep Hurricane Fran made landfall at approximately 2000 EST on 5 September near Wilmington, North Carolina, approximately 160km southwest of Cape Hatteras. Maximum onshore winds reached 19 m/s at 0208 EST on 6 September. The maximum  $H_{mo}$ , at gauge 630, reached 3.4 m ( $T_p=8.3$  s) at 0016 EST on 6 September. There was 5 mm of precipitation.